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practicability. He was no fanatic, but rather a high-bred theorist and reformer." How vividly clear do such facts as these make the remote past appear; and what deep meaning they lend to the words of that greatest of word-painters, Ernest Renan: "A giant even placed on the confines of a picture still remains a giant."

The palace has been exhumed and the pavements—beautifully frescoed with tanks and fishes, birds and lotus plants, and almost unique in their style—have come to light; also inlaid walls and splendid columns inscribed with scenes and capped with capitals imitating "gigantic jewelry." Their surface was encrusted with brilliant glazes, and the ridges between these were gilt, so that they resembled gems set in gold, the effect thus produced reminding the explorers of the "net-work" of the "Temple of Solomon."

Mr. Petrie was also fortunate enough to come across smaller objects, which have thrown light upon the history of the period. In a neighboring quarry he found the name of Queen Thii, the mother of Khu-n-aten, unaccompanied by that of a king. This fact has given him good ground for the suggestion that she may have governed alone during the minority of her son, who, to all appearances, was only married in the fifth year of his reign, his first child having been born in his sixth year. In the fifth year of his reign the king was still called Amenhotep, as shown in a papyrus found at Gurob, but in his sixth year he appears at Tel-el-amarna as Khu-n-aten; so that the great schism which led to the final rupture between himself and the Theban priesthood must have occurred between those two dates.

Moreover, Mr. Petrie has in his possession a scarab on which Amenhotep is represented in adoration before Aten, the name of Amen having been subsequently erased. This scarab finally settles the question, so often raised, of the identity of the man who bore both names.

Relics of the successors of Khu-n-aten—Ra-Saa-Ka-Khepru, Tut-Ankh-Amen, Ai—were also recovered at Tel-el-amarna, showing them to have resided there after him; and even Hor-em-heb left a block of sculpture inscribed with his "cartouche" in the temple of Aten, probably in the early part of his reign and before his compromise with the conservative Theban party. After that time the site was apparently abandoned and no traces remain of further occupation.

The cuneiform tablets discovered in 1887 were all in store-rooms outside the palace, near the house of the Babylonian scribe, which Mr. Petrie identified by finding the "waste pieces of his spoilt tablets in rubbish holes."

A large quantity of Aegean pottery similar to the Mykenæ and Ialysos type was found, of even greater variety of form than that recovered at Gurob. And this as well as the naturalistic character of the frescoes, which Mr. Petrie compares with those of Tiryns and with the gold cups of Vaphio, and the geometrical patterns that decorate some of the columns, which in his opinion closely approach the art of the Mykenæ period, are highly suggestive of Greek intercourse and influence.

The court of Khu-n-aten, in the fifteenth century B.C., must have been a remarkable one. Under the quickening influence of a great mind the foreign conquests of the warlike monarchs of the eighteenth dynasty seem to have been made to yield the richest fruits of peace. A wide-spread intercourse had been established among nations; Phoenicians, Syrians and Mesopotamians, Greeks and Mediterranean Islanders are revealed to us as having come into the Nile valley, bringing along with their commerce their arts, their

industries, and various indirect influences. No wonder that the priests of Amon saw with dread and aversion the influx of foreigners who, encouraged by the evident cosmopolitanism of their king, bid fair to revolutionize the ancient traditions of their venerable land and to remove the narrow boundaries of Egyptian conservatism.

S. Y. STEVENSON.

THE ROLLING OF SHIPS.¹

ONE fact that often strikes the thoughtful traveller by sea is that, notwithstanding the great and numerous improvements of recent years which have made life on shipboard pleasant and luxurious, little or nothing has been done to steady a vessel when she meets with waves that set her rolling heavily from side to side. The tendency seems to be rather in the direction of increased than of diminished rolling; for the steadyng influence of sails, which makes the motion so easy and agreeable in a sailing ship, is fast disappearing in large steamers. Masts and sails add appreciably to the resistance of large fast steamers; so they have been cut down in size year by year till such fragments of sail as still remain are so small compared with the size of the ship as to retain little power to reduce rolling.

Shipowners and seamen do not show much sympathy with the discomfort and misery that rolling causes to most passengers. They perhaps get anxious about an occasional vessel that acquires the evil reputation of being a bad roller, because passengers may be frightened away and the receipts fall off in consequence; but beyond wishing, or attempting, to deal with abnormal cases, nothing seems to be thought of. Rolling is considered incurable, or as not of sufficient importance to trouble about. Yet there is nothing which would contribute so directly to the comfort of landsmen at sea, or do so much to change what is for many misery and torture into comfort, as to check and reduce as far as possible the rolling proclivities of ships.

The laws which govern rolling are now well understood, and it is strange that this knowledge has not enabled an effective means of control to be devised. What is stranger still is that well-known means of mitigating rolling—such as the use of bilge keels—are employed in but very few cases. A ship rolls about a longitudinal axis which is approximately at her centre of gravity, and the rolling is practically isochronous at moderate angles in ordinary ships. The heaviest rolling occurs when the wave-period synchronizes with the natural period of oscillation of the ship. Many vessels are comparatively free from rolling till they meet waves of this period, and if such meeting could be avoided, excessive rolling could be prevented. Some vessels have periods as long as fifteen to eighteen seconds for the double oscillation, and as these would require to meet with waves 1,300 to 1,500 feet in length, in order to furnish the conditions of synchronism, it is seldom that they suffer from heavy or cumulative rolling. Such waves are, however, not rare in the Atlantic.

The limits of heavy rolling are fixed, of course, by the resistance offered by the water and air to the transverse rotation of the ship, which is very great because of the large areas that directly oppose motion in a transverse direction. But for this resistance, and the condition that rolling is only isochronous within moderate angles of inclination, a few waves of the same period as that of a ship would capsize her.

¹ From *Nature*.

The two most obvious modes of preventing heavy rolling are, therefore, (1) to make the period of rolling of a ship as long as possible, so as to reduce the chances of meeting waves whose period will synchronize with it, and (2) to increase the resistance to rolling. The period of a ship varies directly as her radius of gyration, and inversely as the square root of her metacentric height. Hence the period may be increased by increasing the moment of inertia of the ship, or by decreasing the metacentric height. In armored war-vessels the moment of inertia is large, on account of the heavy weights of armor on the sides, and the heavy guns that are either placed at the side or high up above the centre of gravity. Ordinary steamers have no such weights concentrated at great distances from the centre of gravity, and their moments of inertia are determined by the distribution of material in the hull that is fixed by structural conditions and by the stowage required for their voyages. Metacentric height cannot be reduced below a certain amount, which is necessary to prevent too easy inclination of the ship, or crankiness, in still water. On the whole, we may regard the longest periods that the largest ships are likely to have with advantage to be about those named above, i.e., fifteen to eighteen seconds.

Length of period cannot give immunity against occasional heavy rolling; but increase of resistance reduces the angles of roll at all times, and especially when the angular velocity is greatest and the rolling is worst. Such resistance is furnished by the frictional resistance of the bottom of a ship and by the direct resistance of projecting parts of the bottom, such as the keel and the large flat surfaces below at the stem and stern. This resistance can be largely increased by means of bilge keels. The value of bilge keels is recognized in the Royal Navy, and the ships of the navy have been fitted with them for many years with highly beneficial results. The advantage of bilge keels was proved beyond all doubt many years ago by careful experiments made in this country and in France; and the late Mr. Wm. Froude showed, by the trials he made of H.M.S. "Greyhound" twenty years ago, that bilge keels of excessive size—3 feet six inches deep, and 100 feet in length, on a vessel 172 feet long—had only an insignificant effect upon speed throughout great differences of trim.

It is strange that the mercantile marine should not yet have adopted bilge keels, and obtained the undoubted advantage they give in steadiness. The number of ships that have them is comparatively few. There is an almost universal opinion and prejudice against their use, and the largest and finest passenger steamers have no bilge keels. This is in spite of the fact that, in cases where bilge keels have been fitted to try to check heavy rolling—and they have been of suitable size and properly placed—it has been found that the angles of rolling have been reduced by nearly one-half. There is a prevalent belief—which has no foundation in fact—that bilge keels are very detrimental to speed. We have said that Mr. Froude's experiments showed the contrary, even on trials made in still water; but it appears certain that at sea any trifling loss of speed which still-water trials might show would be more than compensated for by gain in speed when the vessel is prevented from rolling through large angles from side to side, and undergoing great changes of underwater form at every roll. Experience with ships that have had bilge keels added after running for some time without them shows that there has been no appreciable difference of speed or increase of coal consumption on their voyages.

Another, and a more heroic, method of stopping or reducing rolling would be to counteract the inclining moment of the ship caused by the ever-changing inclination of the waves by an equal and opposite moment, which would vary as the inclining moment varies. This has been attempted at different times and in various ways. It is essential to any degree of success, however, that the opposing moment brought into operation should be completely under control, so as always to act in the manner and to the extent required. The attempts to obtain a steady platform by freely suspending it, and making it independent of the rolling of the ship, have failed—apart from the practical difficulties of carrying out such an arrangement on a large scale—because the point of suspension oscillates when the ship rolls, and the platform acquires a rolling motion of its own. Weights, made of heavy solid material, which move from one side to the other of a ship subject to the action of gravity and rotation, fail because they cannot be made to act continuously in the manner required.

A degree of success has been achieved by admitting water into a suitably prepared chamber and leaving it free to move from side to side as the ship rolls. This has been done in several ships of the navy, the case of the "Inflexible" being that which was the most carefully experimented upon. The movement of this internal water follows the inclination of the ship, but it lags behind, and thus tends to reduce the inclination. Its effect can be regulated by the quantity of water admitted into the chamber and by its depth. The "Inflexible" committee state in their report that comparatively small changes in depth increase or diminish largely the extintive power of the water. For various reasons—one of which is that while such a chamber is very effective in a moderate sea it fails in a rough sea when the rolling of the ship is greatest—and perhaps partly on account of the destructive and disturbing effect of 100 tons or more of water rushing from side to side of a ship over sixty feet wide—these water-chambers appear to have gone out of use in the navy, and they have been given up in the "City of New York" and "City of Paris," which vessels were said to be fitted with them when first built and placed upon the Atlantic.

Mr. Thornycroft has devised a means of checking rolling by moving a weight, under strict control, from side to side of a vessel so as to continuously balance, or subtract from, the heeling moment of the wave-slope. It consists of a large mass of iron in the form of a quadrant of a circle, which is placed horizontally, with the centre on the middle line of the vessel, and there connected with a vertical shaft. The shaft is turned by an hydraulic engine, which is very ingeniously controlled by an automatic arrangement. The heavy iron quadrant is swept round from side to side, revolving about its centre, to the extent that is required to counteract the heeling moment. In a paper read on the 6th instant before the Institution of Naval Architects, Mr. Thornycroft said:—

"The manner in which the controlling gear works will be better understood if we imagine a vessel remaining upright among waves, while near the centre of gravity of the ship we place a short-period pendulum suspended so as to move with little friction; this will follow the change in the apparent direction of gravity without appreciable loss of time, so that any change in the wave-angle and apparent direction of gravity cannot take place without due warning, which will indicate the time and amount of the disturbance. It is therefore only necessary to make the motion of the

ballast bear some particular and constant ratio to the motion of this short-period pendulum to keep the balance true. The inertia of a heavy mass will cause some loss of time, as we can only use a limited force for its control; but it is possible to accelerate the phase of motion and overcome this difficulty so far as to get good results.

"If, now, we imagine the ship to roll in still water, the effect of the combination just described will be to balance the ship's stability for a limited angle; but this defect is removed by the introduction of a second pendulum of long period, which tends to move the ballast in the opposite direction to the first one, and enables the apparatus to discriminate between the angular motion of the water and that of the vessel.

"I find, however, that the long-period pendulum is rather a delicate instrument, and that its function can be served by a cataract arranged so as to always slowly return the ballast to the centre, and this device has the effect of accelerating the phase of motion, which, in some cases, we also require.

"We are therefore able, by very simple parts, to construct an apparatus which will indicate the direction and amount of motion necessary to be given to the ballast at a particular time so as to resist the wave effort; this power of indicating may be converted into one of controlling by suitable mechanism. The loss of time due to inertia of the necessary ballast is not always unfavorable when the apparatus has to extinguish rolling motion, the greatest effect being obtained when the ballast crosses the centre line of the ship at a time when it is most inclined to the water surface, and this corresponds to a quarter of the phase behind the motion of the short pendulum."

The apparatus has been working for some time in the steam yacht "Cecile" with very good results. What the objections may be to applying it to the largest passenger steamers remains to be seen. A moving weight of something like 100 or 150 tons would probably be required in such vessels. The power necessary to control the movement of the weight appears to be small, and Mr. Thornycroft's invention seems at any rate to show the way towards obtaining the long-desired boon of substantially reducing, if not checking altogether, the rolling of ships. If it succeed in doing upon a large scale only a portion of what is claimed for it in the way of anticipating and counteracting the healing effect of waves, without the possibility of acting in an erratic or undesirable way, we may hope to see it adopted some day in passenger steamers.

LETTERS TO THE EDITOR.

* * Correspondents are requested to be as brief as possible. The writer's name is in all cases required as proof of good faith.

On request in advance, one hundred copies of the number containing his communication will be furnished free to any correspondent.

The editor will be glad to publish any queries consonant with the character of the journal.

A Fire-Ball.

A TELEPHONE wire was supported on cedar posts 20 feet high and 20 rods apart. During last August [1889] we had a thunder-storm, during which there was a sharp and heavy crash. Several of the poles were found to have been struck, and portions to have been taken out through their entire length. One of these portions, of the size of a medium rail, was thrown into an adjoining field some rods from the pole. Portions from the others were smaller and more or less shattered. Near the southernmost pole

struck, a family were in a house with doors and windows open, and a luminous ball seemed to leap from the wire, pass through the open door and a window, and pursue its course some rods through the open space behind the house. A boy in the room grasped his thumb and cried out, "I'm struck," and Mr. Hewett felt a sensation of numbness in his left arm for some time. A girl seized her shawl and rushed out of the house to chase the ball. She reported that she pursued it some distance, while it bounded lightly along, until it seemed to be dissipated in the air without an explosion. The size of the ball was about that of the two fists, and its velocity about that of a ball thrown by the hand.

C. C. BAYLEY.

Lightning.

THE account of a stroke of lightning in *Science* for Jan. 29 last and the article in the issue of April 8 on "The New Method of Protecting Buildings from Lightning" call attention to a subject which has been greatly neglected, viz., the nature, characteristics, and effects of lightning strokes. Besides the passage of the electricity from the cloud to the earth, or the reverse, heavy discharges are always accompanied by other phenomena, which vary on different occasions, and which, for want of record and tabulation, have not yet been explained and their laws determined. In the loose accounts given of them in our daily journals they are spoken of as "freaks of lightning," and no further notice is taken of them. In the hope of doing something towards making a careful record, I offer the following, which has never been published.

The village of Amherst, Mass., is supplied with water from a reservoir among the Pelham hills, about five miles distant. The aqueduct runs nearly in a straight line from east to west. The pipes are made of thick sheet-iron bent into tubes, and the overlapping edges are riveted together with copper rivets about two inches apart. They are covered both without and within with a thick coat of cement. The joints are filled with cement so that the irons do not come in contact, an iron ring five or six inches broad is slipped over the joint, and the whole covered with cement. At a place about half a mile west of the reservoir the aqueduct runs near the foot of a steep hill that is seventy or eighty feet high and covered with a recent growth of white pine, shrub oaks, and yellow birch from ten to thirty feet in height, the intervals of the trees being filled with bushes. During a very heavy shower in July, 1884, a thunder-bolt was seen to fall on the hill. It struck a pine tree half-way down the side of the hill, whose top, on a horizontal line, was not more than two rods from the bottom of the trees on the summit. The tree struck was about twenty-five feet high and eight inches in diameter at the butt. The lightning did not apparently strike it on the top, but about one-fourth of its height from the top, at three equidistant points on the circumference the bark began to be ruptured, and the ruptures continued in straight lines to the ground. There the three currents united, ran over the ground, scattering the dirt and leaves in all directions for two rods, until it came over the aqueduct. There it bored a hole an inch in diameter down to the pipes. It struck about the middle of one of the lengths, broke the cement, and indented the iron as with a heavy blow of a sledge-hammer. The surface of the indentation appeared to have been melted. The current then turned to the west, ran along the top of the pipes, which were full of water under heavy pressure, stripped off the cement and slit the iron tubes through the whole, or a part, of their length. When a line of rivets came in its path, it cut them off between the overlapping edges of the iron as smoothly as with a knife, leaving the parts in each edge undisturbed. At the joints it rent off rings and cement, and indented the edge facing the current, melting the surface as in the place where it first struck the pipe. Rarely was the edge from which the current flowed indented. These effects continued for more than a mile, growing less and less, and finally disappeared.

Several questions in this connection require solution.

1. If the discharge is simply the equalizing of the potential between the cloud and the earth, why was that not accomplished as